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Frustrations and complexity in classical and quantum spin systems

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The origin of complexity remains one of the most important and, at the same time, the most controversial scientific problems. Earlier attempts were based on theory of dynamical systems but did not lead to a satisfactory solution of the problem. I believe that a deeper understanding is possible based on a recent development of statistical physics, combining it with relevant ideas from evolutionary biology and machine learning.

Using patterns in magnetic materials as the main example, I discuss some general problems such as a formal definition of pattern complexity, self-induced spin glassiness due to competing interactions as a way to interpret chaotic patterns, and complexity of frustrated quantum spin systems studied via generalization properties of neural networks used to find the ground state.

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